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MER vistas: ground-truth for Earth-based radar

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Earth-based delay-Doppler radar observations of Mars with four receiving stations were carried out during the Mars oppositions of 2001 and 2003 in support of Mars Exploration Rover landing site selection. This interferometric planetary radar technique has demonstrated radar mapping of Mars with a 5 km spatial resolution. The data for both Gusev Crater and Meridiani Planum indicated very smooth terrains, which can now be quantitatively compared to the surfaces discovered by Spirit and Opportunity.

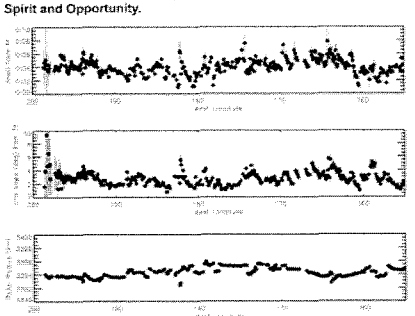
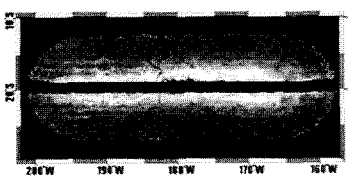


Figure 2. Hagfors' model fit profiles along the sub-radar track on September 27, 2003, at 19.69S. Each data point is the ambiguity weighted average for 5 km x 150 km resolution cell on the sub-radar track. Top is Fresnel reflectivity, middle is rms slope, and bottom is Mars radius.

Figure 3. Much better resolution is obtained away from the sub-radar track, when 4-station interferometry is used to remove the north-south range-ambiguity, to produce the radar backscatter map (5 km per pixel) shown below. Ma'adim Valles leading to Gusev is clearly visible at 185 W.



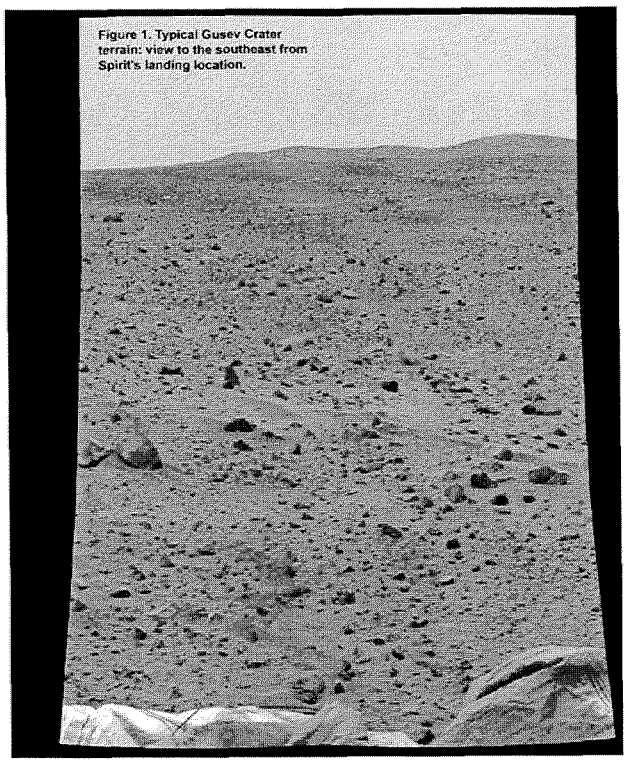


Figure 1. Typical Gusev Crater terrain: view to the southeast from Spirit's landing location.

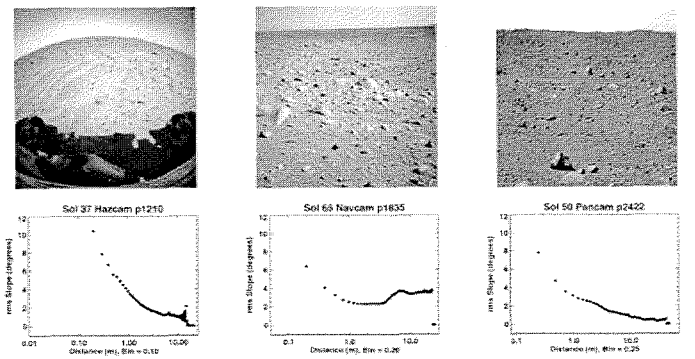


Figure 4. Three views sampling typical terrains encountered by Spirit, and for each the rms slope versus length-scale is plotted from the stereo-derived standard DEM product used by the MER mission. (a) A front Hazcam view on sol 37 (image no. 2F129653855EFF0400P1210L0M1). (b) A Navcam view on sol 65 (2N132143228EFF1600P1835R0M1). (c) A Pancam view on sol 50 (2P130810473EFF1000P2422L7M1).

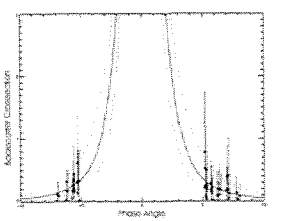


Figure 5. Hagfors' model fit to the 5 km radar cell containing the Spirit landing site. The results of the fit are rms slope = 1.55 +1.0/-0.5 degrees and ρ = 0.02 +0.01/-0.005. The Hagfors' model for quasi-specular scattering estimates rms slope in the 10-100 λ range, or from 0.35 m to 3.5 m in the case of the GSSR experiments. The radar-dervied value falls within this length-scale range in all three cases above.

Conclusions

The rms slopes and surface roughness observed at Spirit's Gusev landing site are in excellent agreement with the rms slopes derived from Hagfors' model fitting of high spatial resolution (5 km x 5 km) Earth-based radar data of the landing site regions. Similar ground-truth agreement is obtained at Meridiani Planum.

Earth-based radar remains a useful tool for probing the global distribution of meter-scale roughness on Mars.

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